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ABSTRACT

This paper highlights the need for a systematic, content aware, and theoretically-based approach to test design. The cognitive components approach is endorsed, and is applied to the development of a computerized perceptual speed test. Psychometric literature is reviewed and shows that: every major multi-factor theory includes a clerical/perceptual speed (CPS) factor; and the CPS factor is defined by tests using number, letter, or figural stimuli, but is best identified with several stimulus types. A computerized CPS test was developed, which contains three subtests: random number strings, random letter strings, and nonsense figure strings. Items are presented in a same/different format that minimizes intersubject and intrasubject strategy variation in search sequencing. Latency and errors should increase as the length of the comparison string gets longer. The slope of a simple linear function should increase as the number of elements increases. Therefore, the length of comparison strings was varied from one to seven elements for number and letter strings, and from one to five for figure strings. In order to obtain normative data, the test was first administered to 435 Navy recruits. Following minor changes, the final version was administered to 722 subjects. Each subject took the three computer CPS subtests and three paper and pencil tests. Results indicate that the computer CPS test was a better psychometric instrument than were the paper and pencil counterparts; it controls speed-accuracy tradeoffs, produces greater individual differences, is more reliable, has greater construct validity, is less "g" loaded, and is probably a purer measure of CPS. This paper calls for the resurrection of the cognitive components paradigm, which combines the knowledge and techniques of psychometric, experimental, and cognitive psychology into a mutually beneficial framework for the test design/development. A 38-item list of references, five data tables, and four figures are included. (RLC)

Revisiting A Cognitive Framework for Test Design: Applications for a Computerized Perceptual Speed Test*

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In the 1970s it appeared that Cronbach's 1957 call to combine correlational and experimental approaches would finally revamp test design procedures, leading to a true science of human abilities and an effective applied psychology. The hope was for theoretically sound tests (Pellegrino & Glaser, 1980; Sternberg, 1977), that would have direct impacts on instructional design (Glaser, 1972), and allow meaningful (and defensible) personnel decisions. Unfortunately, test design continues as it has for decades, beginning with the "creative art" of item writing, and proceeding with atheoretical, content-blind, statistical techniques that maximize the contribution of items to total score variance. Test evaluation is still only a hodgepodge of non-experimental, correlational analyses directed to demonstrate the presence or absence of covariance with other tests. I would like to argue that we are still in dire need of a systematic, content aware, and theoretically based approach to test design.

In the late 70s emerged the ***cognitive components*** approach to test design which provides a useful and consistent framework for test design and evaluation (e.g., Pellegrino & Glaser, 1979; Sternberg, 1977; Whitely, 1980). The approach uses psychometric literature and techniques combined with experimental and cognitive research. Beginning with a problem, the psychometric literature is reviewed, and tests are selected for detailed task analyses. Test items are aggregated and explored to determine consistent sources of item difficulty. The sources of item difficulty are subjected to rational analyses to elucidate the cognitive structures and processes deployed for item solution. This task and rational analysis forms the bases for an information processing model of item solution. Following model specification, experimental items are developed allowing model estimation. Items are administered and model parameters estimated to determine the ***internal validity*** of the model. Internal validity refers to the model's ability to capture performance, and is evaluated in terms of model fit. Finally, the ***external validity*** of the model is evaluated, which refers to how well performance on the experimental task is related to individual differences in performance on the source psychometric test(s).

This framework has great power over traditional approachs to test design. E.g., traditional methods employ statistical (content/process free) criteria for item selection whereas a componential approach uses rule governed criteria for designing/selecting items. The performance model drives item design, reducing uncertainty in creating parallel forms. The process model provides the basis for explaining interitem and intertest correlations which cannot be done with standard psychometric techniques. Thus, theory-based componential tests have greater construct validity (Embretson, 1983). Finally, because the components of item solution are explicitly specified and assessed, componential tests have more diagnostic potential than traditional tests.

A practical example will elaborate the steps in the componential analysis of Clerical/Perceptual Speed (CPS), and the development and evaluation of a computerized CPS test. The U.S. military uses the Armed Services Vocational Aptitude Battery (ASVAB), a collection of 8 power and 2 speeded paper-and-pencil (P&P) tests, to select and classify enlisted applicants (~1 million per year). The two speeded tests are Numerical Operations and Coding Speed; Figure 1 contains examples. These tests are included in the ASVAB to estimate Clerical/Perceptual Speed (CPS) ability. The ASVAB includes CPS estimators because of the extensive evidence for its importance in predicting job and training performance in military and civilian settings (e.g., Ghiselli, 1973; Guilford & Lacey, 1947; Melton, 1947). Unfortunately, the two ASVAB speeded tests are less reliable than (seven of the) power tests and are inadequate measures of CPS; our task is to develop a better one.

With this as background, the psychometric literature was reviewed, showing that every major multi-factor theory includes a CPS factor (e.g., Cattell, 1971; Ekstrom, French, & Harman, 1976; Guilford, 1967; Lohman, 1979; Royce, 1973; Snow, Kyllonen, & Marshalak, 1984; Thurstone, 1938). Figure 2 shows a sampling of CPS test items. There is some question whether there are one or more CPS factors. Sytsma and Ackerman (1987) argue for two distinct classes of CPS tests, one requiring minimal processing (*Sensory*), the other requires greater semantic processing (*Encoding*). Sensory CPS tests require comparisons among nonsense figures, and random letters and numbers. Encoding CPS tests require detecting misspellings, comparing words, and meaningful pictures. Encoding tests are more closely allied with general ability (*g*)

than are Sensory CPS tests. The Sensory–Encoding dichotomy represents a partitioning of a continuum from basic perceptual speed to full semantic processing. Since any partition of the continuum is arbitrary, and to ensure that the resulting measure of CPS is independent of *g*, attention will be focused on Sensory CPS tests. The literature review demonstrated that the CPS factor is defined by tests employing number, letter, or figural stimuli but is best identified with several stimulus types. To summarize thus far, our review has circumscribed the problem area; subsequent steps will focus on Sensory CPS tests using nonsense figures, and random numbers and letters.

Many researchers have noted that CPS tests require rapid and accurate comparisons among strings of symbols, or detection of a symbol in an array of distractors. Careful analysis of items from many tests reveals that the primary source of item difficulty is the length of the symbol strings compared. A rational analysis of the items suggests that item solution requires encoding an element of a string, and then comparing it with the corresponding element of an alternative string. This provides the essence of a cognitive performance model for CPS items. Assume that this Test (T) string *a_b_f* must be compared with this Alternative (A) string, *a_b_c*. The first element of T is encoded and compared with the corresponding element of A. If they match, the next element of T is encoded and compared with A, if they mismatch, processing ceases. This performance model is presented in Table 1. This serial, self-terminating visual search performance model is consistent with the experimental literature on visual search paradigms (Atkinson, Holmgren, & Juol[illegible]969; Bamber, 1972; Luce, 1986; Neisser, 1964; Ratcliff, 1981).

The inform[illegible] so far is sufficient to develop a CPS test and state some hypotheses concerning the per[illegible]nce data. The test was programmed in the language *C*, for administration on a Hewlett–Pacl[illegible] integral PC, running Unix®. The test contains 3 subtests: random number strings, random letter strings, and nonsense figure strings. Items are presented in a same–different format that minimizes inter- and intra-subject strategy variation in search sequencing. Samples are shown in Figure 3. If the cognitive performance model is valid, then latency and errors should increase as the length of the comparison string gets longer. The model specifies that the slope of a simple linear function should increase as the number of elements increases. Therefore, we varied the length of comparison strings from 1-7 elements for number and letter strings, and from 1 to 5 for figure strings.

With the test designed, one issue remained. The experimental literature has long noted that on speeded tests subjects vary with respect to the speed-accuracy tradeoff continuum (Audley, 1973; Fitts, 1966; Krueger, 1978; Pachella, 1974; Ratcliff, 1985). Large differences in speed-accuracy tradeoffs make between subject comparisons impossible. Although the psychometric literature has ignored this problem, we wanted to control the confound. We first administered a long version of the test to 435 Navy recruits. The items were presented in an untimed format; each screen consisted of a single item. This administration provided normative data for each item type, i.e., for each stimulus class (letters, numbers, figures), separately for each level of the number of elements in the comparison strings. These norms were used to set minimum and maximum values on each item type. The computer program was altered to instruct subjects to work as quickly as possible to get 90% of the items correct. They were warned if they took too little or much time on an item. Accuracy and latency feedback was provided after 12 to 14 items. Feedback was adaptive based on prior items, and instructed subjects to slow down (if accuracy was too low), speed up (if accuracy was too high), or simply encouraged continued good performance. The number of items was reduced, and the test was administered to 200 Navy recruits to verify and adjust the timing brackets and instructions. Following small changes, the final version was administered to 722 subjects. Each individual took the three computer CPS subtests and three P&P tests. The P&P tests used number, letter, and figure strings, modeled after the Number Comparison test (Ekstrom, French, & Harman, 1976). Half the subjects took the P&P tests first while the remainder took the computer tests first.

Inherent in the test design are expectations about group and individual subject performance. Confirmation of these expectations constitute support for the ***Internal validity*** of the test. Average accuracy should be 90%. Table 2 shows that accuracy (across contents) was .9006,

suggesting that the test was controlling speed-accuracy tradeoffs. We expected that the number test errors should be less than letters which should be less than figures. The same rankings should be observed for reaction times (RT) (numbers < letters < figures). These hypotheses are based on search set size and stimulus familiarity. While errors were low, number strings produced fewer than letters, and figures had more than either. RTs showed the same ranking, especially with respect to the increase in time needed to compare the nonsense figures. Finally, RT should increase as a linear function of the number of elements in the string. Figure 4 shows plots of the RTs for each subtest by the number of elements, and confirms the hypothesis; the 3 correlations between RTs and number of elements were greater than .989.

While group behavior followed the predicted linear increase, the performance model should also capture individual subject behavior. The model was fit to <u>each</u> subject's data, separately for each subtest, to estimate the degree of model fit (r) which was submitted to a one–tailed significance test. The first column of Table 3 shows the percent of subjects significantly fit by the model; the model fit 99.9% of the subjects on the numbers subtest, 100% on the letters subtest, and 97.8% on the figures subtest. Mean r's were all greater than .97. Clearly, the visual search model captured subject's performance. These results provide strong evidence for the internal and construct validity of the test.

Comparisons between the computer and P&P tests were made to establish the ***external validity*** of the test. The upper panel of Table 4 compares accuracy on the tests. Since the P&P tests have no controls for speed-accuracy tradeoffs, the standard deviations should be greater than the computer tests, which was the case for each subtest and the total test. However, the small standard deviations of the computer tests are an undesirable property of a test designed for predictive validity. Rate scores were calculated as the proportion correct divided by the geometric mean of response times for the computer tests. For the P&P tests, rate was the proportion correct divided by average time per item (time divided by number items attempted). Higher rate scores are better (see Table 5). The second panel of Table 4 shows that the standard deviations of the rate scores for the computer tests are twice as large as the P&P tests. The third panel contains reliability estimates; corrected first-half– second-half correlations. The computer versions are between 17 and 21 points higher. The computer and P&P test intercorrelations are also presented in Table 4. These values are only moderate but are consistent with the literature; the P&P and computer versions of the Differential Aptitude Test's CPS test ranged from .25-.38 (McBride, 1986), and the computer and P&P versions of ASVAB's CPS tests correlated .50 and .51 (Moreno, 1989). Since in all three cases the computer versions have been more reliable, it can be argued that the computer CPS tests are purer measures of CPS – free from answer writing and the resultant brake in concentration. This is supported by the correlation of the ASVAB's g (mean of 8 power tests) and speed measures (mean of NO and CS) with the total score on the computer and P&P CPS tests. While the P&P test is more correlated with speed (.49) than the computer test (.39), the P&P test is also more correlated with g (.23) than the computer test (.15).

Conclusions: This report shows that the computer CPS test is a better psychometric instrument than their P&P counterparts; it controls speed-accuracy tradeoffs, produces greater individual differences, is more reliable, has greater construct validity, is less g loaded and is probably a purer measure of CPS. These data stand on their own but the procedures and rationale need additional comment.

The ***cognitive components*** paradigm combines the knowledge and techniques of psychometric, experimental, and cognitive psychology into a mutually beneficial framework for the design and development of tests. This paper calls for the resurrection of this approach, and provided an example of the development of a Clerical/Perceptual Speed test. Tests developed within this framework have better psychometric properties and greater construct validity. Such tests are consistent with cognitive theory and have greater diagnostic potential since we know what knowledge and cognitive processes are being assessed. In the context of increasing attacks on tests and an ever worsening educational picture, there is even more pressure to alter the business of test design, to produce psychometrically sound, diagnostically useful, and legally defensible testing instruments.

References

Atkinson, R.C., Holmgren, J.E., & Juola, J.F. (1969). Processing time as influenced by the number of elements in a visual display. *Perception & Psychophysics*, **6**, *321–326*.

Audley, R. J. (1973). Some observations on theories of choice reaction time: Tutorial review. In S. Kornblum (Ed.), *Attention and performance IV* (pp. 509-545). New York: Academic Press.

Bamber, D. (1972). Reaction times and error rates for judging nominal identity of letter strings. *Perception & Psychophysics*, **12**, *321–326*.

Carroll, J. B. (1976). Psychometric tests as cognitive tasks: A new "structure of intellect." In L. B. Resnick (Ed.), *The nature of intelligence* (pp.27–56). Hillsdale, NJ: Erlbaum.

Cattell, R. B. (1971). *Abilities: Their structure, growth and action.* New York: Houghton Mifflin.

Cronbach, L. J. (1957). The two disciplines of scientific psychology. *American Psychologist*, **12**, 671–684.

Ekstrom, R. B., French, J. W., & Harman, H. H. (1976). *Manual for the kit of factor-referenced cognitive tests, 1976.* Princeton, NJ: Educational Testing Service.

Embretson (Whitely), S. (1983). Construct validity: Construct representation versus nomothetic span. *Psychological Bulletin*, **93**, 179–197.

Estes, W. K. (1974). Learning theory and intelligence. *American Psychologist*, **29**, 740–749.

Fitts, P.M. (1966). Cognitive aspects of information processing: III. Set for speed versus accuracy. *Journal of Experimental Psychology*, **71**, *849–857*.

Ghiselli, E. E. (1973). [illegible] titude tests in personnel selection. *Personnel Psychology*, **26**, 461–477.

Glaser, R. (1972). Individ[illegible]rning: The new aptitudes. *Educational Researcher*, **1**, *5–13*.

Guilford, J. P. (1967). *The [illegible]man intelligence.* New York: McGraw-Hill.

Guilford, J. P., & Lacey, J. I. (Eds.) (1947). *Printed classification tests.* (Army Air Forces aviation psychology research program reports, No. 5). Washington, DC: U. S. Government Printing Office.

Hunt, E., Frost, N., & Lunneborg, C. (1973). Individual differences in cognition: A new approach to intelligence. In G. Bower (Ed.), *The psychology of learning and motivation* (Vol. 7, pp. 87–122). New York: Academic Press.

Krueger, L. E. (1978). A theory of perceptual matching. *Psychological Review*, **85**, 278–304.

Lansman, M., Donaldson, G., Hunt, E., & Yantis, S. (1982). Ability factors and cognitive processes. *Intelligence*, **6**, 347–388.

Lohman, D. F. (1979). *Spatial ability: A review and reanalysis of the correlational literature* (Tech. Rep. No. 8). Palo Alto, CA: Stanford University, Aptitude Research Project, School of Education.

Luce, R. J. (1986). *Response times: Their role in inferring elementary mental organization.* Oxford Psychology Series (No. 8). Oxford, England: Oxford University Press.

Melton, A. W. (Ed.). (1947). *Army Air Forces Aviation Psychology Program Research Reports: Apparatus Tests. Report No. 4.*. Washington, DC: U.S. Government Printing Office.

McBride, J.R. (1986, August). *A computerized adaptive edition of the Differential Aptitude Tests.* Paper presented at the Annual meeting of the American Psychological Association, Washington, DC.

Moreno, K. E. (1989, March). Personal communication. Data based on a joint-service validity study using the Computerized Adaptive version of the Armed Services Vocational Aptitude Battery. Navy Personnel Research and Development Center, San Diego, CA.

Mumaw, R. J., & Pellegrino, J. W. (1984). Individual differences in complex spatial processing. *Journal of Educational Psychology*, **76**, 920–939.

Mumaw, R. J., Pellegrino, J. W., Kail, R. V., & Carter, P. (1984). Different slopes for different folks: Process analysis of spatial aptitude. *Memory and Cognition*, **12**, 515–521.

Neisser, U. (1964). Visual Search. *Scientific American*, **210** (June), 94–102.

Pachella, R. G. (1974). The interpretation of reaction time in information processing research. In B. Kantowitz (Ed.), *Human information processing: Tutorials in performance and cognition* (pp. 41–82). Hillsdale, NJ: Erlbaum.

Pellegrino, J. W., & Glaser, R. (1979). Cognitive correlates and components in the analysis of individual differences. *Intelligence*, **3**, 187–214.

Pellegrino, J. W., & Glaser, R. (1982). Analyzing aptitudes for learning: Inductive reasoning. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 2, pp. 269–345). Hillsdale, NJ: Erlbaum.

Pellegrino, J. W., & Kail, R. (1982). Process analyses of spatial aptitude. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 1, pp. 311–365). Hillsdale, NJ: Erlbaum.

Ratcliff, R. (1981). A theory of order relations in perceptual matching. *Psychological Review*, **88**, 552–572.

Ratcliff, R. (1985). Theoretical interpretations of the speed and accuracy of positive and negative responses. *Psychological Review*, **92**, 212–225.

Royce, J. R. (1973). The conceptual framework for a multi-factor theory of individuality. In R. J. Royce (Ed.), *Multivariate analysis and psychological theory* (pp. 305–407). New York: Academic Press.

Snow, R.E., Kyllonen, P.C., & Marshalak, B. (1984). The topography of ability and learning correlations. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence (v. 2)* (pp. 47-104). Hillsdale, NJ: Erlbaum.

Sternberg, R. J. (1977). *Intelligence, information processing and analogical reasoning: The componential analysis of human abilities.* Hillsdale, NJ: Erlbaum.

Sternberg, R. J., & Gardner, M. K. (1983). Unities in inductive reasoning. *Journal of Experimental Psychology: General*, **112**, 80–116

Sytsma, M. R. & Ackerman, P. L. (1987, August). *Abilities for skill acquisition: A study of perceptual speed.* Paper presented at the 1987 Annual meeting of the American Psychological Association, New York, New York.

Thurstone, L. L. (1938). *Primary mental abilities.* Chicago, IL: University of Chicago Press.

Whitely, S. E. (1980). Modeling aptitude test validity from cognitive components. *Journal of Educational Psychology*, **72**, 750–769.

Table 1.

Serial Visual Search Model for Perceptual Speed Items

Start

Encode T_i

Encode A_i

Compare T_i *with* A_i

if $T_i \neq A_i$

Respond ***nomatch*** go to Exit

else

if $T_i = A_i$ *and*

if $i < I$

then $i = i + 1$

go to Start

else

if $i = I$ then

Respond ***match*** go to Exit

Exit

Table 2.

Total CPS Test

Accuracy = .9006

CPS Subtests		
	Errors	**Reaction Time (sec)**
Numbers	.097	1.232
Letters	.099	1.340
Figures	.106	1.795

Table 3.

Symbol	% Fit	*r*	ACC	RT (s)
Numbers	99.9	.973	.903	1.232
Letters	100.0	.975	.901	1.340
Figures	97.8	.982	.894	1.795

Table 4.

Accuracy				
	Computer		P and P	
	Mean	SD	Mean	SD
Numbers	.903	.053	.940	.065
Letters	.902	.054	.875	.089
Figures	.894	.058	.894	.087
Total	.901	.049	.902	.071

Rate				
	Computer		P and P	
	Mean	SD	Mean	SD
Numbers	.677	.088	.242	.046
Letters	.627	.094	.221	.041
Figures	.614	.081	.187	.036
Total	.645	.078	.217	.036

Reliability		
	Computer	P and P
Numbers	.93	.74
Letters	.90	.72
Figures	.88	.71
Total	.96	.75

Correlations	
	Computer-P&P
Numbers	.46
Letters	.50
Figures	.43
Total	.54

Table 5.

Relationship between Latency and Accuracy for Rate Score

$$\text{Rate} = \frac{1/N \sum_{i=1}^{N} A_i}{\left(\prod_{i=1}^{N} L_i\right)^{1/N}} = \frac{\text{Proportion Correct}}{\text{Geometric Mean Latency}}$$

Proportion Correct	Latency (seconds)							
	.25	.50	.75	1.0	2.0	3.0	4.0	5.0
.65	2.60	1.30	.87	.65	.33	.22	.16	.13
.70	2.80	1.40	.93	.70	.35	.23	.18	.14
.75	3.00	1.50	1.00	.75	.38	.25	.19	.15
.80	3.20	1.60	1.07	.80	.40	.27	.20	.16
.85	3.40	1.70	1.13	.85	.43	.28	.21	.17
.90	3.60	1.80	1.20	.90	.45	.30	.23	.18
.95	3.80	1.90	1.27	.95	.48	.32	.24	.19
1.00	4.00	2.00	1.33	1.00	.50	.33	.25	.20

Figure 1.

NUMERICAL OPERATIONS

Directions

Now look at the sample problem below.

S1. 3 X 3

S1-A 6
S1-B 0
S1-C 9
S1-D 1

The answer is 9, so the C answer is correct.

CODING SPEED

Directions

Look at the practice key and the five sample questions below.

KEY

green 2715	man 3451	salt 4586
hat 1413	room 2864	tree 5972

SAMPLE QUESTIONS	ANSWERS				
	A	B	C	D	E
S1. room	1413	2715	2864	3451	4586
S2. green	2715	2864	3451	4586	5972
S3. tree	1413	2715	3451	4586	5972
S4. hat	1413	2715	3451	4586	5972
S5. salt	1413	2864	3451	4586	5972

Notice that each of the questions is one of the words in the key table. To the right of each question are possible answers listed under the letters A, B, C, D, and E. The word in Question S1 is "room." By looking in the key you see that the code number for room is 2864. Among the five possible answers for Question S1, 2864 is listed under choice C, so C is the correct answer. The word for Question number S2 is "green." By looking in the key you see that the code number for green is 2715. Among the possible answers, 2715 is listed under choice A, so A is the correct answer.

Figure 2.

658331	____	656331	5173869	____	5172869
11653	____	11652	6430017	____	6430017
617439428	____	617439428	518198045	____	518168045
1860439	____	1860439	55179	____	55097
90776105	____	90716105	63216067	____	63216057

Cross out words containing an 'a'.

picnic	other	person
smart	straw	warm
finger	noisy	juice
useful	defer	enter
slowly	field	ordeal
meant	mend	nurse
quick	skill	cool

Figure 3.

Examples

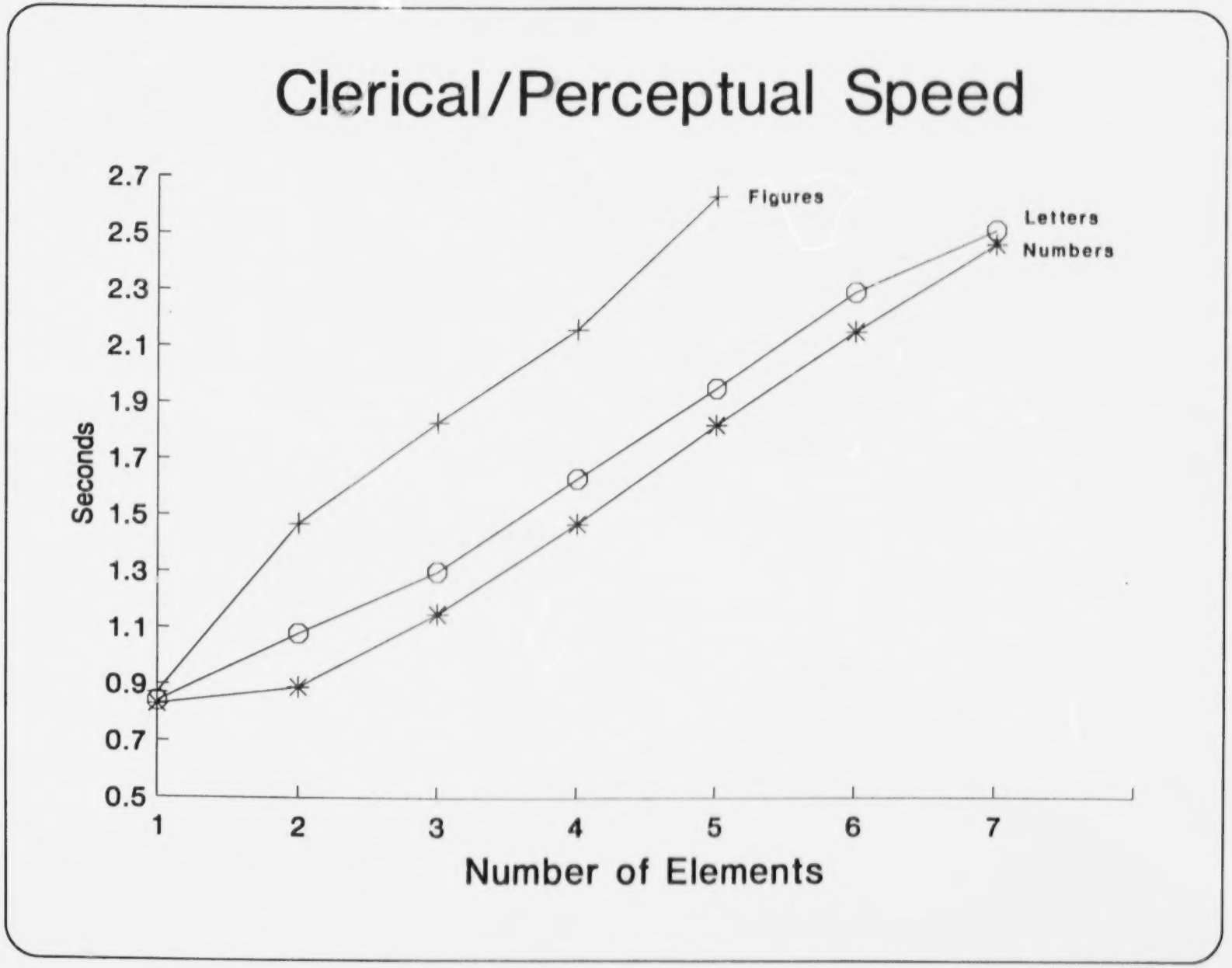
9873 ____ 9863

lrpaxd ____ lrqaxd

Ψ‡Ø∩ ____ Ψ‡Ø∪

Note: The Figures example is contrived. Ten meaningless, asymmetric figures were actually used and created from either two (5 figures) or three (5 figures) line segments.

Figure 4.


Clerical/Perceptual Speed
Seconds
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
Figures
Letters
Numbers
1
2
3
4
5
6
7
Number of Elements